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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention requires between the method member of outside, and inner direction members for the rolling device used as a conductive state, In particular, in information machines and equipment, such as business machines, such as a copying machine and a laser beam printer, and a hard disk drive (a spindle motor, a swing arm), other motors, etc., it is related with the rolling device used suitably.

[0002]

[Description of the Prior Art]In a common business machine and information machines and equipment, for example, a copying machine, much anti-friction bearings are used for the movable part. Between the raceway surface of the inside-and-outside ring of this anti-friction bearing, and the rolling element, the oil film is formed during rotation, and said raceway surface and said rolling element serve as non-contact. Since static electricity occurs with said rotation in such anti-friction bearing, inconvenience, like the radiated noise has adverse effects, such as distortion, on the copied image of a copying machine may arise.

[0003]In order to prevent such inconvenience from arising, by enclosing conductive grease with the inside of a bearing, Anti-friction bearing (patent No. 2579798) which made the conductive state an internal and external bearing ring and rolling element, and anti-friction bearing (JP,8-5370,Y) which made the conductive state between internal and external bearing rings by having a seal which has conductivity while enclosing conductive grease with the inside of a bearing are proposed.

[0004]

[Problem(s) to be Solved by the Invention]However, in anti-friction bearing provided with the seal which has the above conductivity, when turnover time turns into a long time, base oil oozes from conductive grease and an oil film may be formed in the slide contact portion of a seal and an inner ring of spiral wound gasket (such a phenomenon is described as "an oil blot" henceforth). If it does so, since a seal and an inner ring will be in a noncontact state, the conductivity between inside-and-outside rings will be checked, and the electric resistance value between inside-and-outside rings will become large.

[0005]Thus, since static electricity occurred with rotation of anti-friction bearing when the electric resistance value between inside-and-outside rings became large (electrification), there was the same inconvenience as the above-mentioned, i.e., a possibility that the radiated noise of static electricity may have an adverse effect on the apparatus by which this anti-friction bearing is used. For example, when

this apparatus was a copying machine, there was a case where distortion etc. arose in a copied image by a radiated noise.

[0006]Then, let it be a technical problem for this invention to solve the problem which the above conventional rolling devices have, to maintain the conductive state between the method member of outside, and an inner direction member good over a long period of time, and to provide the rolling device which electrification does not produce easily.

[0007]

[Means for Solving the Problem]In order to solve said technical problem, this invention consists of the following composition. Namely, two or more rolling elements in which a rolling device of this invention was allocated between a method member of outside, an inner direction member, and a method member of said outside and said inner direction member enabling free rolling, In a rolling device provided with lubricant arranged inside said sealing member between a sealing member which it is attached to one side among a method member of said outside, and said inner direction member, and carries out sliding contact to another side, and a method member of said outside and said inner direction member, While said sealing member has conductivity, volume resistivity at least one side of a portion which \*\*\*\*s to a method member of said outside, or said inner direction member among said sealing members, a portion which \*\*\*\*s to said sealing member among a method member of said outside, or said inner direction member, and \*\*  $1 \times 10^{-7}$  ohm-cm. It covered to a conductive lubricating oil below  $10^{-7}$  ohm-cm.

[0008]If it has such composition, even if an oil blot will arise to said lubricant and an oil film will be formed in a slide contact portion of a method member of said outside or said inner direction member, and said sealing member, By operation of said conductive lubricating oil, since the conductivity of a method member of said outside or said inner direction member, and said sealing member is maintained, A conductive state between a method member of said outside and said inner direction member is maintained good over a long period of time (an electric resistance value between a method member of said outside and said inner direction member stabilized in a good value, and maintained), and it is hard to produce electrification.

[0009]The volume resistivity of said conductive lubricating oil needs to be below  $1 \times 10^{-7}$  ohm-cm. A conductive state between a method member of said outside and said inner direction member falls that it is an excess of  $1 \times 10^{-7}$  ohm-cm (an electric resistance value between a method member of said outside and said inner direction member becoming large), and there is a possibility that electrification may arise. A thing which made a conventional lubricating oil dissolve or distribute a compound, a conductive substance (it is described as a conducting agent henceforth), etc. which have high polarity as said conductive lubricating oil is used suitably. As for concentration of a conducting agent, at this time, it is preferred to consider it as 1 - 20wt%. Volume resistivity of a conductive lubricating oil becomes being less than [ 1wt% ] with an excess of  $1 \times 10^{-7}$  ohm-cm. Even if it uses it exceeding 20wt%, an effect of lowering volume resistivity of a conductive lubricating oil further is not expectable.

[0010]As a compound which has high polarity, a hydrocarbon system compound etc. which have oxygen which is a hetero element are raised into molecular structure, such as an ester bond and an ether bond, and, specifically, a surface-active agent which has the antistatic effect illustrated below is preferred. Namely, the Nonion system surface-active agents, such as a sorbitan fatty acid ester, a glycerine fatty acid ester, polyglyceryl fatty acid ester, polyoxyethylene alkyl phenyl ether, and polyoxyethylene alkylamine fatty acid amide, N-acylamino acid. Or the salt, polyoxyethylene-alkyl-ether acetate, a polyoxyethylene-alkyl-ether phosphate, alkyl sulfocarboxylate, alkyl phosphoric acid or

its salt, polyoxyalkylene alkylether phosphate, or its salt, They are ampholytic surface active agents, such as cation system surface-active agents, such as anionic system surface-active agents, such as aromatic phosphoric ester, alkyl ammonium salt, and an alkyl benzylammonium salt, an acetic acid betaine, and imidazolinium betaine.

[0011]As a conductive substance, there are an electron donor acceptor complex and an ion conductivity substance. As an electron donor acceptor complex, there is a molecular compound formed by electron donors (donor), such as aromatic compounds, hetero aromatic compounds, and amines, and electron acceptors (acceptor), such as halogen and tetracyano quinodimethane (TCNQ). If in the form of a donor/acceptor shows an example of this molecular compound, BIIRANTOREN/iodine, pyrene/iodine, Pyridazine/iodine, N-n-butylisoquinolinium / TCNQ, tetrathio full BAREN / TCNQ, N-methyl phenazine / TCNQ, tetraseleno full BAREN / TCNQ, hexamethylenetetraseleno FURUBAREN / TCNQ, octadecylpyridine / TCNQ, There is lithium/TCNQ, tetrathio full BAREN / a 2,4,6-Tricia NOTORI azine.

[0012]what combined crown ether, polyalkylene glycol, etc. and a metal ion as an ion conductivity substance -- a conductive polymer of low molecular weight is raised comparatively. If it uses for a conductive lubricating oil combining plurality of the above conducting agents, an effect of a conductive lubricating oil may be able to be heightened further. That is, it is preferred to mix two or more sorts in a surface-active agent which has the antistatic effect, an electron donor acceptor complex, and an ion conductivity substance, and to use as a conducting agent.

[0013]Said lubricant arranged inside said sealing member between a method member of said outside and said inner direction member is grease, When this grease contains an additive agent with comparatively low volume resistivity like extreme pressure agents, such as antioxidants, such as dialkyl diphenylamine, and tricresyl phosphate, Since conductivity between a method member of said outside and said inner direction member improves according to a synergistic effect with a conducting agent in a conductive lubricating oil, it is desirable.

[0014]A kind in particular of lubricating oil used for a conductive lubricating oil is not a thing limited, and can illustrate a lubricating oil of common use of a poly alpha olefin system, an ester system, an ether system, a glycol system, an alcohol system, a fluorine system, etc. Since it has lubricity, and the conductive lubricating oil can give lubricity to a slide contact portion of a method member of said outside or said inner direction member, and said sealing member, it is preferred. However, if it is a range which can give lubricity to this slide contact portion, even if it mixes and uses an organic solvent etc. for a lubricating oil, it will not interfere.

[0015]Although a method in particular of covering said sealing member, a method member of said outside, and said inner direction member to such a conductive lubricating oil is not limited, a method of applying or spraying a conductive lubricating oil is the most common. If an oil repellent agent which has the character which crawls lubricant (or the base oil) arranged inside said sealing member between a method member of said outside and said inner direction member is applied a slide contact portion and near [ its ] a method member of said outside or said inner direction member, and said sealing member, Since an oil film becomes an oil blot is controlled and is hard to be formed in a slide contact portion of a method member of said outside or said inner direction member, and said sealing member, it is desirable. Then, a conductive state between a method member of said outside and said inner direction member is maintained good over a long period of time, and it is hard to produce electrification.

[0016]If this oil repellent agent is applied at least to one side of a portion which \*\*\*\*s to a method

member of said outside, or said inner direction member among said sealing members, a portion which \*\*\*\*s to said sealing member among a method member of said outside, or said inner direction member, and \*\*, the above-mentioned effect will be acquired, but. It may apply not only over said slide contact portion but over its neighborhood. This oil repellent agent may be applied to said conductive lubricating oil in piles, and may avoid and apply a portion which applied said conductive lubricating oil. As such an oil repellent agent, an oil repellent agent of a fluorine system is used preferably.

[0017]in addition -- a case where a rolling device is anti-friction bearing with a method member of said outside in this invention -- an outer ring of spiral wound gasket -- the same -- a case of a linear guide device -- a slider, similarly in the case of a ball screw, a ball screw nut is meant, respectively. moreover -- a case where a rolling device is anti-friction bearing with said inner direction member in this invention -- an inner ring of spiral wound gasket -- the same -- a case of a linear guide device -- a guiding rail, similarly in the case of a ball screw, it \*\*\*\*s, and an axis is meant, respectively.

[0018]

[Embodiment of the Invention]The embodiment of the rolling device concerning this invention is described in detail, referring to drawings. Drawing 1 is drawing of longitudinal section showing the structure of the ball bearing 21 which is one embodiment of the rolling device concerning this invention. This ball bearing 21 is \*\* constituted with the contacted type seals 26 and 26 which consist of two or more balls 24 allocated between the outer ring of spiral wound gasket 22, the inner ring 23, and the outer ring of spiral wound gasket 22 and the inner ring 23 enabling free rolling, the cage 25 holding two or more balls 24, and India rubber 26a and the metal rodding 26b.

[0019]This seal 26 is attached to the seal groove 22b of the outer ring of spiral wound gasket 22, and is carrying out sliding contact of that lip part 26c to the peripheral face of the inner ring 23. And the space surrounded with the outer ring of spiral wound gasket 22, the inner ring 23, and the seals 26 and 26 is filled up with the conductive grease 27, and it is sealed by ball bearing 21 inside with the seals 26 and 26. And with this conductive grease 27, while the lubrication of the contact surface of the raceway surfaces 22a and 23a of said both wheels 22 and 23 and the ball 24 is carried out, the outer ring of spiral wound gasket 22, the inner ring 23, and the ball 24 are a conductive state. The outer ring of spiral wound gasket 22 or the inner ring 23 is grounded (not shown), and the static electricity generated by rotation of the ball bearing 21 is removed.

[0020]This conductive grease 27 is the thing which gave conductivity to lithium soap synthetic oil grease by adding the conductive solid powder in metal powder, the end of carbon powder (for example, carbon black), etc. Since such conductive grease 27 has the lubricity which was excellent with conductivity, it is hard to produce metallic contact of the raceway surfaces 22a and 23a of the ball bearing 21, and the ball 24, and an oxide film cannot generate it easily to the raceway surfaces 22a and 23a. As a result, it is hard to produce a conductive temporal fall.

[0021]The usual grease (it does not have conductivity) may be used instead of the conductive grease 27. Not grease lubrication but the oil lubrication to a lubricating oil may be sufficient as the lubricating method of the ball bearing 21. India rubber 26a of the seal 26 is constituted by conductive rubber, and the seal 26 has conductivity. And since the lip part 26c of the seal 26 is in slide contact with the peripheral face of the inner ring 23, it is a conductive state via the seal 26 between the outer ring of spiral wound gasket 22 and the inner ring 23.

[0022]At least to one side of the portion which is in slide contact with the peripheral face of the inner ring of spiral wound gasket 23 among the lip parts 26c, and the portion which is in slide contact with the

lip part 26c among the peripheral faces of the inner ring of spiral wound gasket 23. The conductive lubricating oil (the concentration of aromatic phosphoric ester is 5wt%) which dissolves aromatic phosphoric ester (conducting agent anionic system surface-active agent) which is an anionic system surface-active agent in a diester oil (lubricating oil) is applied. The volume resistivity of this conductive lubricating oil is below  $1 \times 10^7$   $\Omega$ -cm and a small value.

[0023] Since the small conductive lubricating oil of volume resistivity exists in the slide contact portion of the seal 26 and the inner ring of spiral wound gasket 23, even if an oil blot arises with the conductive grease 27 and an oil film is formed between the lip part 26c of the seal 26, and the peripheral face of the inner ring of spiral wound gasket 23, the conductivity of the seal 26 and the inner ring of spiral wound gasket 23 is maintained. Therefore, the conductive state between the outer ring of spiral wound gasket 22 and the inner ring 23 is maintained good over a long period of time (the electric resistance value between the outer ring of spiral wound gasket 22 and the inner ring 23 stabilized in a good value, and maintained), and it is hard to produce electrification.

[0024] If it has applied to the above-mentioned part at least, sufficient effect will be acquired, but even if it applies a conductive lubricating oil even near the part, it does not interfere. For example, it may apply to the whole surface of the seal 26. The oil repellent agent is applied to the seal 26 and the inner ring of spiral wound gasket 23. Since this oil repellent agent has the character which crawls the base oil of the conductive grease 27, an oil blot is controlled and the oil film has become is hard to be formed in the slide contact portion of the seal 26 and the inner ring of spiral wound gasket 23. Therefore, the conductive state between the outer ring of spiral wound gasket 22 and the inner ring 23 is maintained more good over a long period of time, and it is difficult to produce electrification.

[0025] This oil repellent agent is enough if it has applied without the portion which \*\*\*\*s to the peripheral face of the inner ring of spiral wound gasket 23 among the seals 26 and its neighborhood, and the portion which \*\*\*\*s on the seal 26 among the peripheral faces of the inner ring of spiral wound gasket 23 and its neighborhood, but it may be applied to the whole surface of the seal 26. Such a ball bearing 21 has the good conductivity between both wheels 22 and 23, and since it is hard to produce electrification and the state is maintained good over a long period of time, its a possibility of having an adverse effect on the apparatus by which the radiated noise of the electrified static electricity arises, and the ball bearing 21 is used is small. Therefore, it can be conveniently used for information machines and equipment, such as business machines, such as a copying machine and a laser beam printer, and a hard disk drive, other motors, etc.

[0026] This embodiment shows an example of this invention and this invention is not limited to this embodiment. For example, the kind of the conducting agent which the kind of conductive lubricating oil is not limited to the above-mentioned example, and is used for a conductive lubricating oil, and lubricating oil is satisfactory at all, if it describes above in the paragraph of The means for solving a technical problem.

[0027] In this embodiment, although the ball bearing was an inner ring rotary type type, outer ring rotation form may be sufficient. In this embodiment, although the ball bearing was illustrated and explained as a rolling device, the rolling device of this invention is applicable to various rolling devices of other kinds. For example, it is suitably [ for rolling devices such as various anti-friction bearings other than a ball bearing, a ball screw, a linear guide device, and a direct-acting bearing, ] applicable.

[0028] Next, the electric resistance value between the inside-and-outside rings under rotation is measured about the above-mentioned ball bearing 21 and several sorts of ball bearings of the almost same

composition, and the result of having evaluated the grade in which conductivity carries out aging is explained. First, the device which measures resistance is explained, referring to the outline lineblock diagram of drawing 2.

[0029]Among drawing 2, by expressing the ball bearing of a measuring object and rotating the shaft member 2 attached to the inner ring of spiral wound gasket 1a by the motor 3, the numerals 1 are constituted so that the bearing 1 may be rotated. And while a predetermined constant voltage is impressed between the shaft member 2 and the outer ring of spiral wound gasket 1b which are united with the inner ring 1a, the measure resistance device 5 is connected by the constant voltage power supply 4 in parallel with the constant voltage power supply 4 concerned then.

[0030]The measure resistance device 5 outputs the measured pressure value (analog value) to the A/D conversion circuit 6. The A/D conversion circuit 6 is changed into a digital value with the sampling period set up beforehand, and outputs the changed digital signal concerned to the arithmetic processing unit 7. According to this embodiment, the sampling period is set as 50 kHz (sampling time intervals = 0.02 ms).

[0031]The arithmetic processing unit 7 is provided with the following.

The maximum resistance operation part 7A.

Threshold processing part 7B.

Wave number counting part 7C.

The maximum resistance operation part 7A calculates the maximum resistance based on the inputted digital signal. The threshold processing part 7B performs a threshold process with a prescribed threshold value about the inputted digital signal, and removes noise. About the pulse count from the threshold processing part 7B, by the increasing and decreasing change of a temporal pulse value, the wave number counting part 7C counts the transaction count for every predetermined time unit, i.e., the wave number of a wavy mountain, and calculates the average value of the wave number per the unit time. The arithmetic processing unit 7 outputs the calculated maximum resistance and the average value of the wave number per unit time to the display 8.

[0032]According to this embodiment, the unit time which counts the above-mentioned wave number is set as 0.328 second. The display 8 comprises a display etc. and displays the maximum resistance which the arithmetic processing unit 7 calculated, and the average value of the wave number per unit time. Next, how to evaluate the electric resistance value of the ball bearing 1 using the device of the above-mentioned composition is explained.

[0033]Where it drove the motor 3 and the shaft member 2 1a, i.e., an inner ring, is rotated with prescribed rotational speed, a predetermined constant voltage is impressed from the constant voltage power supply 4 between the inside-and-outside ring 1a of the bearing 1, and 1b. Although current flows between the inside-and-outside ring 1a and 1b at this time, voltage is changed by a spark etc. The voltage is measured with the measure resistance device 5, and continues, it is changed into a digital value, the arithmetic processing unit 7 asks for the maximum resistance and the wave number per prescribed unit time based on the digital signal, and the value is displayed on the display 8 by the A/D conversion circuit 6.

[0034]About three kinds of bearings (Examples 1 and 2 and comparative example 1) of composition of mentioning later, the device of the above-mentioned composition was used and the inside-and-outside ring 1a under rotation and the electric resistance value (maximum) between 1b were measured every 100 hours. A measurement result is shown in the graph of drawing 3, and a measuring condition is shown

below.

- revolving speed [ of the shaft member 2 ]: -- radial road (Fr):9.8N and turnover time given to 300 rpm and the bearing 1 : 600 hour and seal-of-approval voltage : 6.2V and maximum current : 100microA and ambient temperature: -- 25 \*\* and atmosphere humidity: -- 50%RH and sampling period: -- 50 kHz, Although the bearing of the 0.328-second examples 1 and 2 and the comparative example 1 is the almost same composition as the above-mentioned ball bearing 21, the bearing of Example 1 applies a conductive lubricating oil and an oil repellent agent to the slide contact portion of the seal and inner ring of spiral wound gasket which have conductivity (that is, it is the completely same composition as the ball bearing 21). And the seal has shown the graph of drawing 3.

[0035]The bearing of Example 2 is what applied only the conductive lubricating oil to the slide contact portion of the seal and inner ring of spiral wound gasket which have conductivity (the oil repellent agent has not applied), and other composition is the same as that of the ball bearing 21. And \*\* seal has shown the graph. The bearing of the comparative example 1 has applied neither the conductive lubricating oil nor the oil repellent agent to the slide contact portion of the seal and inner ring of spiral wound gasket which have conductivity, and other composition is the same as that of the ball bearing 21. And <> seal has shown the graph.

[0036]The relative value when the resistance in 100 hours of the bearing of the comparative example 1 is set to 1 shows the resistance of the vertical axis in the graph of drawing 3. The size is 8 mm in inside diameter, 22 mm in outer diameter, and 7 mm in width, and the filling quantity of conductive grease of any bearing is 155-165 mg. When it passed over 200 hours so that a graph might show, to resistance having risen rapidly, the bearing of the comparative example 1 had stable resistance, even if the bearing of Examples 1 and 2 passed over 200 hours, and the effect which applied the conductive lubricating oil was seen. Especially the bearing of Example 2 had stable resistance till 600 hours, and was understood that spreading of an oil repellent agent is dramatically effective.

[0037]Next, a conductive lubricating oil is explained. First, the ratio of a conducting agent (the compound and conductive substance which have high polarity), and a lubricating oil is explained. In the conductive lubricating oil in which drawing 4 consists of polyoxyethylene-alkyl-ether phosphate (conducting agent) which is an anionic system surface-active agent, and a diester oil (lubricating oil), It is a graph (measurement temperature is 25 \*\*) which shows the relation between the addition of polyoxyethylene-alkyl-ether phosphate, and the volume resistivity of a conductive lubricating oil.

[0038]The volume resistivity of a conductive lubricating oil becomes that the addition of a conducting agent is less than [ 1wt% ] with an excess of  $1 \times 10^7$  omega-cm so that a graph may show, but if it is more than 1wt%, volume resistivity will serve as a small value called below  $1 \times 10^7$  omega-cm. However, as for the addition of polyoxyethylene-alkyl-ether phosphate, since the effect of lowering volume resistivity more is not expectable even if it adds exceeding 20wt%, it is preferred to consider it as 1 - 20wt%.

[0039]The bearing for which drawing 5 used the above conductive lubricating oils (the composition of those other than a conductive lubricating oil) It is a graph which shows the result of having evaluated the increasing rate of the electric resistance value between inside-and-outside rings at the time of rotating a bearing over 300 hours about it being the same as that of the above-mentioned ball bearing 21 (the method and conditions of measurement are the same as the case of above-mentioned drawing 3). The horizontal axis of a graph is an addition of polyoxyethylene-alkyl-ether phosphate in a conductive

lubricating oil. And the vertical axis of a graph is an increasing rate of the resistance of a before [ from rotation 100 hours / 300 hours ] (that is, the relative value which set the resistance at the time of 100-hour rotation to 1 shows the resistance at the time of 300-hour rotation).

[0040]The graph of drawing 5 shows that aging (rise) of the electric resistance value of a bearing can be suppressed small, when the volume resistivity of a conductive lubricating oil is below  $1 \times 10^7$   $\Omega$ -cm (that whose polyoxyethylene-alkyl-ether phosphate addition is 5wt% and 10wt%). Therefore, it can be said also from this that it is necessary to make said addition more than 1wt%.

[0041]These tendencies are almost the same even if it is a case where the combination of a conducting agent and a lubricating oil is others.

[0042]

[Effect of the Invention]As mentioned above, the conductive state between the method member of outside and an inner direction member is maintained good over a long period of time, and electrification does not produce the rolling device of this invention easily.

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[Translation done.]